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The Novel Circular Microstrip Patch Antenna

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***Abstract*– A novel transmission line model is represented to model bowtie patch antennas. The purposed model uses two slots for modeling the radiation from patch sides. Each radiation slot is presented by parallel equivalent admittance. Also in this model mutual coupling and the effect of slots length limitation as well as the influence of the side slots on the radiation conductance are taken into account implicitly. Admittance and controlled source equations that used for rectangular patch antenna are modified.**

***Index Terms*– Transmission Line, Monopole Antenna and Wideband**

I. INTRODUCTION

THERE are numerous substrates that can be used for the design of microstrip patch antennas and their dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 12$.

Those desirable for antenna performance are thick substrates whose dielectric constant is in the lower end of the range due to better efficiency, (Lewin, 1960).

Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design.

The radiating element and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangle, thin strip (dipole), circular, elliptical, triangle or any other configuration [1].

II. ULTRA WIDEBAND MONOPOLE ANTENNA WITH SPLIT RING RESONATOR AS FILTER

The last years a special attention has been devoted to the development of Ultra Wideband (UWB) monopole antennas [2], [3]. The UWB is a short-range wireless technology for transmitting large amounts of data at very high-speed with very low power antennas, but in a compact planar configuration, such as bowtie, diamond, circular and elliptical disc dipoles.

A) Important parameters of antenna

To describe the performance of an antenna, definitions of various parameters are necessary. In practice, there are several commonly used antenna parameters, including frequency bandwidth, radiation pattern, directivity, gain, input impedance, and so on.

B) Frequency bandwidth

The frequency bandwidth of an antenna can be expressed as either absolute band- width (ABW) or fractional bandwidth (FBW). If fH and fL denote the upper edge and the lower edge of the antenna bandwidth, respectively. The ABW is defined as the difference of the two edges and the FBW is designated as the percentage of the frequency difference over the center frequency, as given in Equation (1) and (2), respectively.

$$ABW = f_H - f_L \tag{1}$$

$$FBW = 2\frac{f_H - f_L}{f_H + f_L} \tag{2}$$

For broadband antennas, the bandwidth can also be expressed as the ratio of the upper to the lower frequencies, where the antenna performance is acceptable, as shown in Equation (3):

$$BW = \frac{f_H}{f_L} \tag{3}$$

C) Directivity and Gain

To describe the directional properties of antenna radiation pattern, directivity D is introduced and it is defined as the ratio of the radiation intensity U in a given direction from the antenna over that of an isotropic source. For an isotropic source, the radiation intensity U0 is equal to the total radiated power P_{rad} divided by 4π. So the directivity can be calculated by:

$$D = \frac{U}{U_0} = \frac{4\pi U}{P_{rad}} \tag{4}$$

If not specified, antenna directivity implies its maximum value, i.e., D0.

$$D_0 = \frac{U|_{max}}{U_0} = \frac{U_{max}}{U_0} = \frac{4\pi U_{max}}{P_{rad}} \tag{5}$$

D) Radiated field

To obtain the fields radiated by the current element, it is required to determine magnetic vector potential $\vec{A}$ first.

For Hertzian Dipole, $\vec{A}$ is expressed as [4]:

$$\vec{A} = \frac{\mu_0 I_0 dl}{4\pi r} e^{-jkr} \vec{z} \tag{6}$$

In the spherical coordinate, Equation (6) is transformed to:

$$A_r = A_z \cos\theta = \frac{\mu_0 I_0 dl}{4\pi r} e^{-jkr} \cos\theta$$

$$A_\theta = -A_z \sin\theta = -\frac{\mu_0 I_0 dl}{4\pi r} e^{-jkr} \sin\theta$$

$$A_\varphi = 0 \tag{7}$$

According to Maxwell's equations and the relationship between $\vec{A}$ and $\vec{H}$:

$$\nabla \times \vec{E} = -j\omega\mu\vec{H}$$

$$\vec{H} = \frac{1}{\mu} \nabla \times \vec{A} \tag{8}$$

Now E- and H field can be found:

$$H_r = H_\theta = 0$$

$$H_\varphi = j\frac{kI_0 dl\sin\theta}{4\pi r}\left[1 + \frac{1}{jkr}\right] e^{-jkr}$$

$$E_r = \eta \frac{I_0 dl\cos\theta}{2\pi r^2}\left[1 + \frac{1}{jkr}\right] e^{-jkr}$$

$$E_\theta = j\eta \frac{kI_0 dl\sin\theta}{4\pi r}\left[1 + \frac{1}{jkr} - \frac{1}{(kr)^2}\right] e^{-jkr}$$

$$E_\varphi = 0 \tag{9}$$

In the far-field region where $kr \gg 1$, the E- and H-field can be simplified and approximated by:

$$E_\theta \approx j\eta \frac{kI_0 dl sin\theta}{4\pi r} e^{-jkr}$$

$$E_r \approx E_\varphi = H_r = H_\theta = 0$$

$$H_\varphi \approx j\frac{kI_0 dl sin\theta}{4\pi r} e^{-jkr} \tag{10}$$

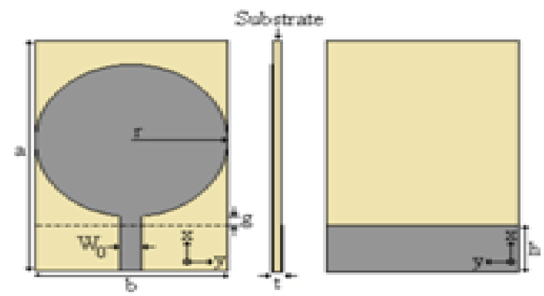
The ratio of E_θ and H_φ is:

$$Z_\omega = \frac{E_\theta}{H_\varphi} \approx \eta \tag{11}$$

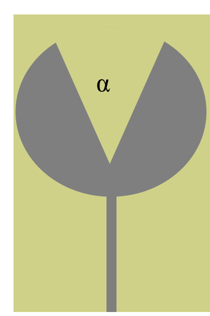
where Z_ω is the wave impedance; η is the intrinsic impedance of the medium ($377 \approx 120\pi$ Ohms for free space).

III. ANTENNA DESIGN

A compact printed microstrip-fed monopole antenna is presented in (Fig. 1).The design consisted of a circular shaped perfect electric conductor printed on a partial grounded ARLON DICLAD dielectric substrate of 2.17 permittivity, 0.768 mm thick.



(a)



(b)

Fig. 1: (a) Circular microstrip antenna
(b) Circular microstrip antenna with triangular slot

For this investigation, a circular monopole antenna was chosen as a starting point. A monopole antenna is a type of radio antenna formed by replacing one half of a dipole antenna with a ground plane at right angles to the remaining half. If the ground plane is large enough, the monopole behaves like a dipole, as the reflection in the ground plane behave as the missing half of the dipole, except that the radiation from the reflected half is added to that of the real half (see image antenna).

Table 1: Dimension antenna

Parameter	Dimension (mm)
a	30
b	20
g	1
r	10
h	6
w_0	2.4
l	0.768

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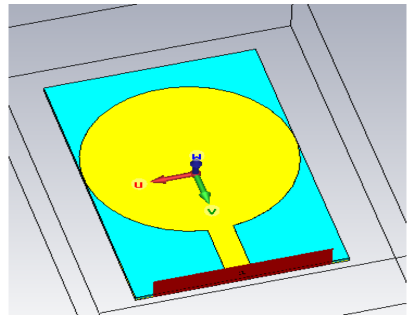
IV. RESULTS AND DISCUSSION

The structure shown above was considered to start the experimental research implementation, performed with the construction and measurement, while the Computer Simulation Technology: Microwave Studio (CST MWSTM) was used as an auxiliary tool in the simulation process

The simulated S11 return loss results for this monopole antenna are shown in (Fig. 1). In the computer aid simulation an Arlon DiClad 880TM substrate with coppered plates on both sides was used.

The return loss for the antenna is shown in (Fig. 2). The new design has the same dimensions as the first one and the rectangular cut has the width equal 2.4 mm which is equal to the microstrip feeding line W0. It can be seen that with the rectangular cut introduction the bandwidth is increased by about 17%, in the improved bandwidth the S11 is below −10 dB form 4.9 GHz to 7.4 GHz.



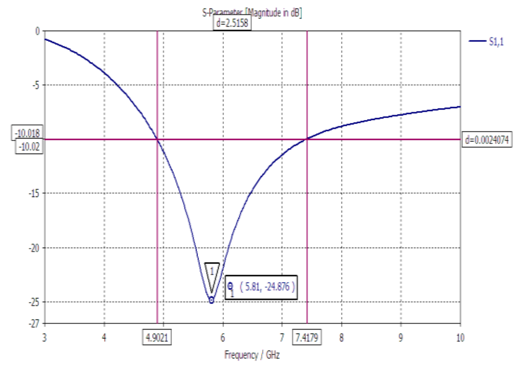


Fig. 2: Circular microstrip antenna for (CST MWSTM)

The return loss of Circular microstrip antenna with triangular slot (α=30°) is shown in (Fig. 4). The resonant frequency of this design is at 4.24 GHz with - 39.671 dB of return loss. The - 10 dB bandwidth of this design is at the frequency between 3.51 GHz and 9.58 GHz.

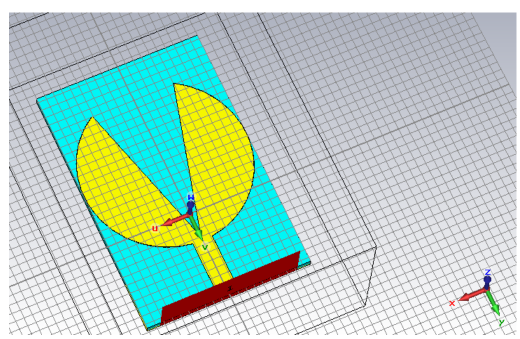


Fig. 3: Circular microstrip antenna with triangular slot for (CST MWSTM)

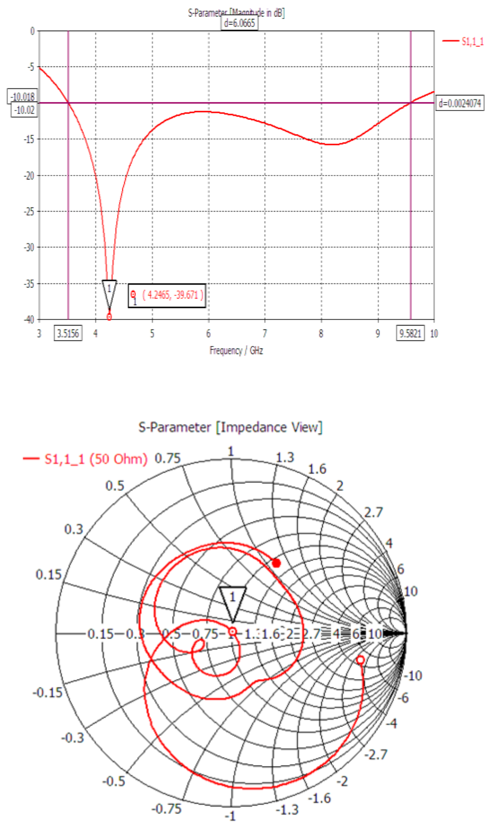


Fig. 4: Return loss and Smith Chart results Circular microstrip antenna with triangular slot for (CST MWSTM)

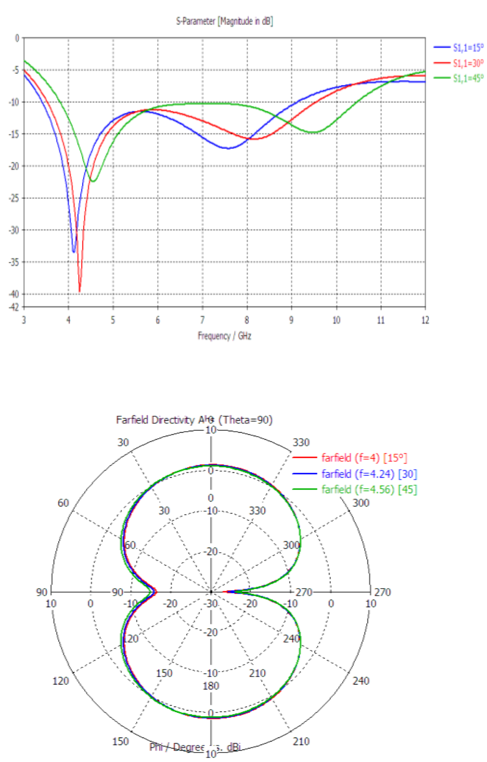


Fig. 5: Return loss and Farfield Directivity Abs (Theta=90) Circular microstrip antenna
with different angle -triangular slot (α=15°; 30°; 45°)

Table 2: Return loss, f_c and Bandwidth of patch antenna with different angle

Circular antenna				Pattern
f_c	S11(dB)	Bandwidth (GHz), *f1-f2* (GHz) (-10dB)	α	/
5.81	-24.87	6.07;(03.51 - 09.58)	0°	A
Circular antenna with triangular slot				
4.00 GHz	-33.27	5.72;(03.41 - 09.13)	15°	B
4.24 GHz	-39.66	6.02;(03.52 - 09.54)	30°	C
4.56 GHz	-22.39	6.65;(03.81 - 10.46)	45°	D

Different variation Return loss also affects the performance of the patch antenna. Fig. 5 and Table 2 show that Pattern B and C give the best S11 results with (-33.27dB, -39.66 dB) while Pattern A and Pattern D score poorly with(-24.87dB, -22.39 dB). The patterns C and Pattern D show the best resonant frequency and bandwidth that are (4.24GHz, 4.56 GHz)and (6.02 GHz, 6.65 GHz).

III. CONCLUSION

Lately, many researchers have started to look into UWB with the development of the latest communication systems, and a surge of research interest into small UWB antennas has been raised. Such antennas have to be small enough to be compatible to the UWB unit and omnidirectional radiation patterns are often required for UWB terminal antennas. Finally, a good time-domain characteristic, i.e., a good impulse response with minimal distortion is also required for transmitting and receiving antennas. The second family is due to further developments on broadband monopole antennas, in which planar elements, such as circular, square, elliptical, pentagonal and hexagonal discs appear.

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